SEL

max-100
FREQUENCY COUNTER

GLOBAL SPECIALTIES
An Interplex Electronics Company

INSTRUCTION MANUAL

80-01-0019

100 MEGAHERTZ 8 DIGIT COUNTER
MAX–100

GENERAL SPECIFICATIONS

FREQUENCY 5 Hz TO 100 MHz
8 DIGIT DISPLAY 7 SEGMENT LED

INPUT CHARACTERISTICS

Impedance: 1.5 megohm resistance shunted with 10 picofarads

Connector: phono jack

Coupling: AC

Sine Wave Sensitivity:

40 mV,	5 Hz –	1 KHz
30 mV,	1 KHz –	100 KHz
10 mV,	100 KHz –	10 MHz
40 mV,	10 MHz –	60 MHz
120 mV,	60 MHz –	100 MHz

Count Accuracy: Time base accuracy ± 1 count

Overload: peak AC or DC

5 Hz – 30 KHz	200Vpk
30 KHz – 70 KHz	150Vpk
70 KHz – 100 KHz	125Vpk
100 KHz – 1.0 MHz	42Vpk
1 MHz – 10 MHz	13.8Vpk
10 MHz – 60 MHz	6.4Vpk
60 MHz – 100 MHz	5.4Vpk

Time base:

Crystal Osc.:	3.579545 MHz
Temp. Stability:	5 – 45°/C
	.1 ppm/°C
Aging Rate:	10 ppm/Yr
Accuracy:	± 3 ppm at 25°C
Trimmer Adjustable:	± 40 ppm
Gating Time:	1.0 sec
Update Time:	1/6 sec

Lead Zero Blanking – for all but the least significant digit.

Automatic MHz Decimal Point – when the display shows greater than 1 MHz, decimal point appears between the sixth and seventh digit.

Low Battery Indicator – when the battery voltage drops to 6.6V, display will pulse on and off at a one-second rate.

Batteries:

6 NiCad (fast charge)	AA-type
6 Alkaline	AA-type

Net Weight: 1.5 lbs. max (0.68Kg)

Size: 1.75x5.62x7.75"
(45x143x197mm)

INTRODUCTION

Congratulations! With your purchase of the MAX-100, you have acquired one of the most advanced, most versatile digital frequency counters available today. Thanks to the latest LSI integrated-circuit technology and advanced engineering techniques, the MAX-100 is a sensitive, highly accurate instrument providing both precision, accurate frequency measurement and operating simplicity.

1. **Full 8-Digit display covers 100 MHz range,** with frequency resolution of 1 Hz, from 5 Hz to 100 MHz.
2. **No front panel controls** — MAX-100 is **completely** automatic; range, polarity, slope, trigger, or input level switching is not required.
3. **Extra-large .43" display** — display count is easily readable from 20 feet away.
4. **Lead-zero blanking** — All zeros to the left of the first non-zero digit are blanked. The least significant digit is always active.
5. **Automatic decimal point** — A decimal point appears between the 6th and 7th digit when the input frequency exceeds 1 MHz.
6. **Input overvoltage protection** — the counter input circuits are diode protected, and can be placed across AC power lines without damage to the unit.
7. **Automatic overflow indication** — the most significant digit will blink when the input signal exceeds 100 MHz.
8. **Automatic low-battery indicator** – The **entire** display blinks when battery voltage drops below a preset level (6.6VDC). However, the display will still read correctly. Pulsing the display in this manner actually **extends** remaining battery life.

All these features and more has made MAX-100 the finest frequency counter in its price range today.

In order to get maximum usage from your MAX-100, please read this **entire** manual carefully. Besides comprehensive instructions describing the use of the MAX-100 and its accessories, this manual will acquaint the user, who is new to digital frequency measurement, with the basics of counter technology.

HOW FREQUENCY COUNTERS WORK

GENERAL

Figure 1. shows a block diagram of MAX-100. It consists of four sections:

1. Front End (input amplifier)
2. Main Counter
3. Display
4. Time Base

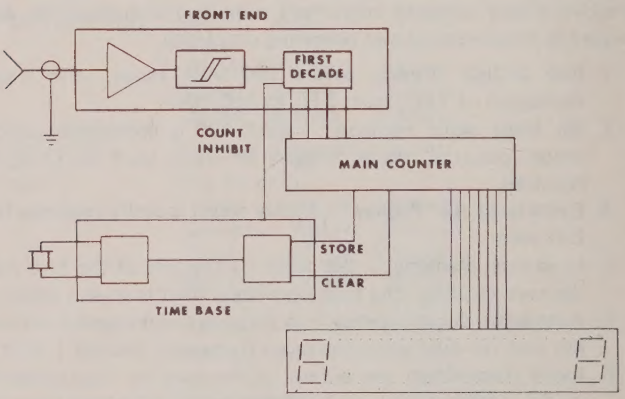

fig. 1

The front end processes the input signal and conditions it for the high-speed decade counter that follows it. The counter output is then fed into the main counter, where the major portion of signal processing is done. Measurements are sorted into digits and updated periodically, by precise timing commands from the time-base section. Once a measurement is ready for display, it is converted from a binary code to a display code, and finally fed to the eight seven-segment LED read out.

The time base section generates a precision 1-second gate pulse for the main counter and the required signals to process the input signal. Each section will be dealt with in more detail, but first consider the basic TIMING CYCLE of the MAX-100.

THE TIMING CYCLE

Figure 2A shows a timing diagram, with the series of pulses required to process the input signal.

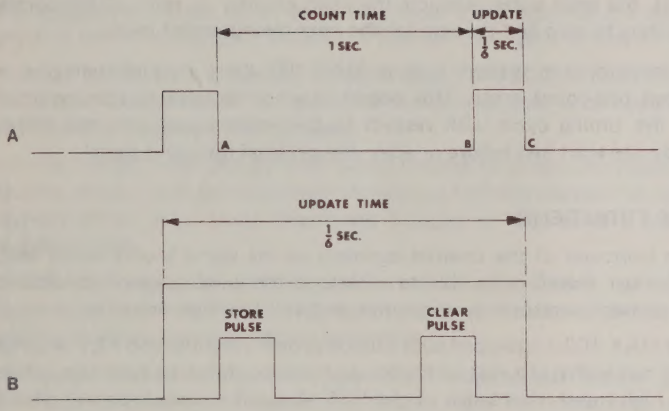

fig. 2

The top waveform shows a 1-second downtime between points A and B, followed by a 1/6-second pulse width. This is the **count inhibit waveform**, that controls the first decade counter in the front end. Since all signals coming in must first pass through the first decade divider, control of the main counter can be achieved by switching the first decade divider on and off.

Assume that the main counter has been cleared and all digits are zero. At point A in the Figure 2A, the first decade is switched on and starts to accumulate (count) incoming pulses.

At point B in the Figure 2A, the first decade counter is switched off and all pulses that have entered it during this time interval have been sorted and stored in the main counter.

At this point the update cycle begins. Figure 2B shows the **updated waveform** in detail.

Shortly after the start of the update pulse a **store pulse** commands the main counter (that has held all the pulses in temporary registers), to feed data into the storage latches. The latches (that have been storing data from a previous measurement), now accept the new measurement. The latches will store the new measurement until the next store pulse occurs.

Due to the manner in which the input signals are scanned, the display is always one (1) measurement period (1 sec.) behind. This is not a major concern since the input frequency should be fairly constant and not change widely from measurement to measurement.

Next, the **reset pulse** instructs the main counter to reset all temporary registers to zero and prepare for the next measurement cycle.

In asyncronoum systems such as MAX-100, there is an inherent plus or minus one-count error. This occurs due to the random starting point of the timing cycle with respect to the input signal; i.e., the timing cycle can start just before or after one cycle of the input signal.

THE FRONT-END

The front-end of the counter connects to the signal source under test, and must therefore be able to withstand the wide range of conditions the owner/operator may encounter, and still function properly.

The MAX-100 is equipped with a diode-protected wideband FET preamp that can withstand vast overloads and still continue to function, while the high input impedance of the FET allows it to couple to any circuit with a minimum of loading.

Once a test signal has passed the FET preamp, it is presented to a series of low-noise preamps that amplify it to a suitable level to operate a schmitt trigger. In order to improve its stability and reduce noise, the signal is converted into a series of fast-rise-time pulses, after which it passes on to the first decade divider.

The first decade divider is a specially-designed high-speed decade counter, whose output data is in a coded form that the main counter cannot decipher. Therefore, a decoder is inserted between the decade divider and the main counter in order to recode the data into a format the main counter can process.

This switching of codes back and forth occurs quite often in digital circuitry and is used several times in the MAX-100.

MAIN COUNTER AND DISPLAYS

The Main Counter is a 40-pin Large Scale Integrated Circuit chip, containing all the latches and registers required to display an 8-digit binary coded digital (BCD) output. It also contains the logic to produce an 8-bit strobe system, scan oscillator, lead zero blanking system, overflow latch, and decimal point blanking.

Here the data is processed as described previously. Held in registers during the measurement period, the new measurement is finally transfered to the display latches.

Each latch services one digit of the display and has four output lines.

The display scanning logic sequentially samples the four (4) lines.

The displays are made up of seven individual LED segments per digit, which in combination can produce any number from zero to nine.

In order to produce a number on the display, the BCD outputs from the Master Counter must be converted into a code that is compatable with the seven segment LED displays.

In most designs each display latch would require its own seven segment decoder driver, each decoder driver requiring a limiting resistor for each segment driven thus 7 segments times 8 digits, or 56 resistors and 8 decoder drivers.

In order to reduce the circuitry cost, a multiplexing system has been incorporated that requires a single seven segment decoder driver, seven limiting resistors, and eight driver transistors.

The system sequentially switches each 4 BIT latch to the decoder, and simultaneously turns on the associated display digit. Therefore, only one digit is active at any one time. The switching from digit to digit is extremely rapid and beyond the ability of the human eye to discern, thus the eye "sees" a continuous 8-digit display.

There is a twofold benefit in multiplexing the LED displays: first, circuit simplification and second, an increase in the **efficiency** of the LED display.

Since each digit is on only 1/8th of the time, in order to achieve the same brightness as a continuous display, the LED current must be increased eight times. Interesting results are produced via this process. LED efficiency increases with current, a pulsed LED giving off more light than a steady-state LED for the same current. The human eye does not average pulsed light linearly. It tends to see pulsed light as actually **brighter** than it normally is, thus allowing the reduction in display current (which is a major portion of our power drain), and still maintaining a bright discernible display.

TIME BASE

The Time Base section is the master "clock" for the counter, and as such, it must produce highly accurate stable pulses. It also must produce all the store, clear, reset and update pulses needed to route the digital traffic correctly.

A specially selected 3.58 MHz crystal provides the precision frequency source for the time base.

When used in conjuction with a special oscillator divider I.C., it produces an ultra stable 60 Hz output, which is divided down to 1Hz. The

remainder of the control pulses are selected from the 60Hz to 1Hz divider chain.

The oscillator divider chip is voltage-regulated from a special power line to insure a maximum degree of stability.

The time base accuracy is ± 4 ppm. This means plus or minus 4 Hz at 1 MHz or ± 400 Hz at 100 MHz.

All time base circuitry is voltage regulated, to insure that battery or line voltage changes will not have any effect on time base accuracy.

USING YOUR COUNTER

Introduction

The MAX-100 was designed for utter simplicity of operation. The complete absence of range switches allows the user to simply turn on the power switch, connect the input leads to a signal source, and take a reading.

Checking out your MAX-100

In order to use the MAX-100 on AC, insert the plug at the end of the 100 CA1 or 100 CA2 adapter/charger into the power jack at the rear of MAX-100. Then insert the adapter/charger into a convenient wall socket.

For battery operation, slide off the battery panel on the bottom of the MAX-100 and insert batteries into the battery case inside the chamber. If non-rechargeable cells are used, make sure they are alkaline (AA) type.

If nickel cadmium cells are used, make sure they have been fully charged. See that switch is in correct position for battery being used (Rechargeable or Alkaline).

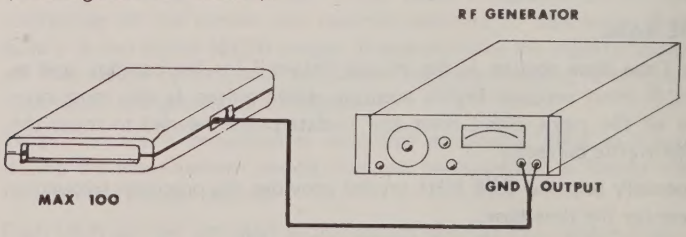

fig. 3

Figure 3 shows the test arrangement for checking your MAX-100.

The RF generator should have a frequency range of 1 MHz to greater than 100 MHz, with a variable output voltage that is greater than 120 millivolts RMS.

Connect the test cable supplied with the MAX-100 to the input jack on the right-hand side of the counter, and connect the clip lead end of the cable to the RF generator output.

Switch on the power to the MAX-100. This is achieved by pushing the slide switch next to the input phono jack up toward the top of the case. (White Dot)

Apply power to the RF generator and allow adequate time to stabilize (3-5 min.). Set the RF generator frequency to 2 MHz and increase the output level control to 10 millivolts RMS.

MAX-100 should now read close to 2 MHz (most RF generators do not have the dial accuracy to tune exactly to a frequency).

Adjust the generator frequency to just greater than 2 MHz.

The MAX-100 should display a 2 on the seventh digit to the left with the lighted decimal point on its right. This is the MHz decimal point and it lights as long as the signal exceeds 1 MHz.

Now tune the RF generator as close to 2.001000MHz as possible. The lower order digits may change (this is caused by drift in the RF generator). If the generator is top-quality, only the first two right-hand digits should change. By now, you can see that the counter updates every second, and you may have noticed that it takes two or three counts for the MAX-100 to stabilize when the signal input is changed.

Tune the RF generator to 95 MHz and increase the output level to 120 mV RMS. The MAX-100 should track the RF generator. Slowly increase the RF generator frequency until the display reads greater than 100 MHz.

At this point, the extreme left hand digit will flash a zero, and the counter will read above 100 MHz. Simultaneously, the lead zero blanking is inhibited, and all leading zeros will appear. The counter acts as if a ninth digit has displayed a 1, and displays the count above 100 MHz, including the zeros.

Typically, MAX-100 should be able to count to 110MHz.

TAKING RELIABLE READINGS

There are certain rules to follow for reliable readings. These are based on knowing the following:

1. The signal source characteristics
2. The counter input characteristics
3. The coupling between source and counter

SIGNAL SOURCE CHARACTERISTICS

The MAX-100 has an input sensitivity of less than 40 millivolts, from 5 Hz to 50 MHz. However, if the signal source is basically noisy the counter will read a meaningless jumble of numbers. The first rule is to know the signal to noise ratio. **40 dB or greater** (one hundred to one) is needed in order to get a meaningful reading.

SIGNAL STABILITY AND MODULATION

Knowing the signal source also means knowing its frequency stability.

When testing CB transmitters, a clean crisp reading is always achieved because the transmitter is crystal controlled.

However, many signal or function generators are **not** very frequency stable, being approximately in the 1% to 5% range. They are prone to frequency modulation which appears to the counter as noise, and causes jumbling of the lower order digits.

MAX-100 INPUT CHARACTERISTICS

The MAX-100 input circuit consists of a 330 ohm resistor in series with a 1 megohm resistor, shunted by a 10 pF capacitor (see Figure 4).

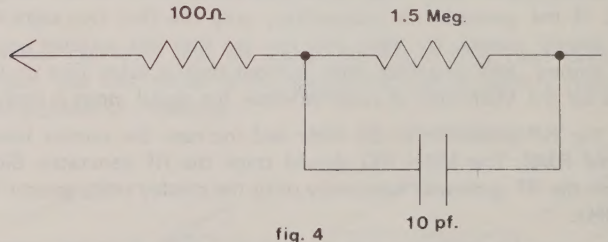

fig. 4

At audio frequencies, the capacitive reactance of the 10 pF capacitor is so high that effectively, the input network looks like several hundred kilohms to any circuit it is testing.

At RF frequencies such as CB, the 10 pF capacitor is now approaching 560 ohms impedance. Although the input impedance can never go

below the 100 ohm input resistor, it can approach it. Therefore, some care should be taken in hooking up to RF systems.

When measuring the frequency of an RF oscillator coil an effective impedance of 600 ohms is seen by the coil. In some cases the 600 ohm load may inhibit oscillation.

There are, however, no loading problems when connecting to a 50-ohm transmission line termination, and the hookup does **not** affect the power match.

COUPLING LINES AND CABLES

The coupling device between the signal source and the counter can be a critical point in acquiring accurate readings.

Most shielded cable has approximately 25 pf of capacity per foot. A four foot cable will appear as a 100 pf capacitor. When it is connected to a source generator with a 100 kilo ohm output impedance that is generating a 150 kilohertz signal, the cable will load down the signal output to 1/10th its open circuit voltage. Therefore it is important to:

1. Keep all lines as short as possible; and
2. Understand that cables can load high impedance signal sources and **detune** resonated signal sources.

AUDIO TESTING

Audio signals can have their special problems. One of the most common is high frequency noise spikes on the audio signal. A small series of "glitches" or pulses at 30 MHz may get lost in the total one-second count time. However, at one kilohertz the same series of glitches may represent **30%** of the count.

Therefore, it is most important to keep audio signals free of spikes.

One remedy for this is to place a small bypass capacitor across the counter input leads. (50 to 1000 pF)

Another problem enountered more often in audio than in RF testing, is outside interference being sensed by the test set up.

Audio circuitry in general use higher impedance sources than RF and are, therefore, more sensitive to random power line spikes and outside interference.

A good rule to follow is **always use a shielded cable** such as the one provided with your MAX-100 when testing audio (#100-IPC). **Keep unshielded connections as short as possible.**

OVERFLOW INDICATOR

When the input signal frequency exceeds 100 MHz, the lead zero blanking is removed and the most significant digit will blink.

The counter will still read correctly, in most cases up to 110 MHz. However, input signals of **greater** than 300 mV may be needed in order to obtain a reading.

DECIMAL POINT

When the input frequency exceeds 1 MHz, a decimal point automatically appears between the sixth and seventh digits to indicate a signal in the Megahertz range.

LOW BATTERY INDICATOR

When the battery voltage drops below 6.6 volts, the display will blink at a one-second rate. **The display will still read correctly and the counter will be usable for some time.**

The blinking display not only indicates a low battery voltage, **it also reduces the display current by 50% thereby extending the remaining battery life.**

The remaining usable life in a set of batteries depends on several factors: intermittent or continuous use, and the type of batteries used.

Battery life and characteristics will be discussed in the next section.

RECALIBRATION OF THE MAX-100

These steps will allow you to recalibrate your MAX-100 Frequency Counter against an accurate frequency standard.

REQUIRED EQUIPMENT:

FREQUENCY STANDARD

A 10 MHz crystal oven with a $1V_{p\text{-}p}$ output is recommended. A stability of at least ±1 ppm is required, ±0.5 ppm recommended. Other accurately-known frequencies may be substituted (see step 7).

TUNING WAND

A non-conductive, non-capacitive screwdriver-type tool must be used to adjust the trimmer capacitor within the MAX-100.

PHILLIPS-HEAD SCREWDRIVER

PROCEDURE:

1. Disconnect all power and input cables and accessories from the MAX-100.
2. Remove the top cover by first removing the four (4) Phillips-head screws from the underside of the MAX-100 (see Figure 5), then gently lifting off the top cover.
3. Check to be sure that both the power jack assembly plate and the input jack/power switch assembly plate are properly seated in the case bottom and that nothing is shorting.
4. Carefully connect the frequency standard output to the MAX-100 input and power up first the MAX-100, then the frequency standard. For best results, the ambient temperature during the following procedures should be the same as the temperature at which the MAX-100 is normally used. Allow 1-hour minimum warmup period before proceeding to step 5.
5. Because the MAX-100 typically responds to the cooling effects of operation with its top cover removed by shifting down 15 counts, we will be trimming for a reading of 9,999,985. Since at 10 MHz our specified accuracy of ±4 ppm ±1 count is equivalent to a permitted deviation of 31 counts, a reading between 9,999,954 and 10,000,016 suits our requirements. Note that since frequency drift due to aging tends to be upward, it is best to seek a reading on the lower end of this range.
6. Once calibrated, temporarily remove power from the MAX-100, disconnect the power and signal leads, reassemble the MAX-100 case, reconnect the leads, and again power up the MAX-100. Perform these operations quickly. Then monitor the readings on the MAX-100 during the course of a minimum four to five hour "burn-in" period. Normal drift of a few counts centered near 10,000,000 (or near some value between 9,999,969 and 10,000,031) is acceptable.
7. Use the following formulas to calculate the acceptable range of readings for ±4 ppm ±1 count accuracy at any given standard frequency. (Remember to adjust for a reading 15 counts lower than the standard frequency when the MAX-100 is operated with its cover removed).

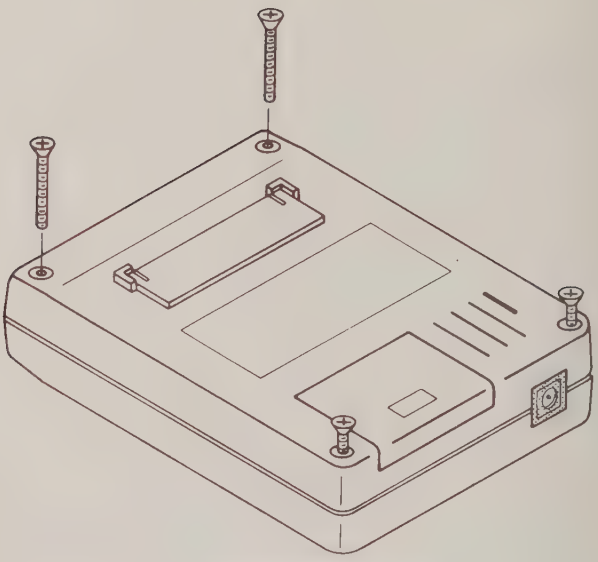

fig. 5 TO DISASSEMBLE THE MAX 100

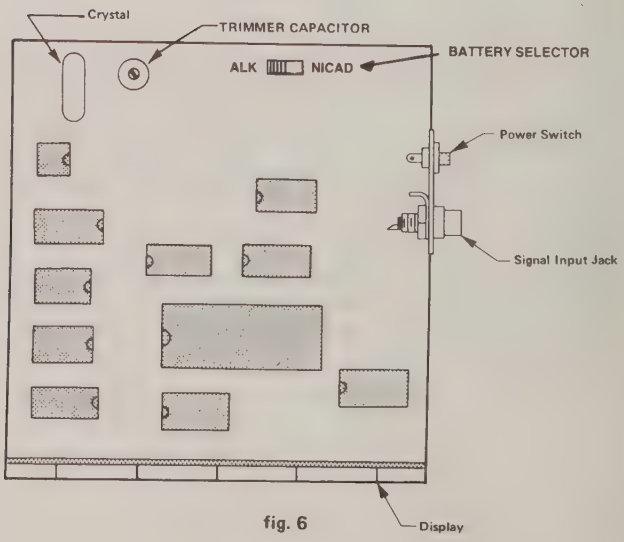

fig. 6

First, determine the acceptable deviation, *D*, as follows:

$$D = (F_S \times 10^{-6} \times (3 - E_S)) + 1$$

where D = acceptable deviation
F_S = frequency of the standard, in Hertz
E_S = error of the standard, in ppm

Then *R*, the acceptable range of readings on the MAX-100, falls between these limits:

$$R_{lim} = F_S \pm D$$

Or, with the case cover off:

$$R_{lim} = F_S - 15 \pm D$$

EXAMPLE:

With a 50 MHz ± 1 ppm standard:

$D = (50{,}000{,}000 \times 10^{-6} \times (3 - 1)) + 1 = 101$
R_{lim} = 50,000,000 ± 101 with the cover on
= 50,000,000 − 15 ± 101 = 49,999,985 ± 101 with the cover off

so R must fall between 49,999,899 and 50,000,101 with the cover on, between 49,999,884 and 50,000,086 with the cover off.

BATTERIES AND ACCESSORIES

MAX-100 can be powered by either 6 nickel cadmium rechargeable cells or 6 alkaline cells, both of the AA type.

Each type will give adequate performance, with nickel cadmium (NiCad) having a little longer life than alkaline.

Figure 7 shows the discharge curves for both alkaline and NiCad cells. Alkaline starts off with a higher voltage, but falls off much more rapidly than NiCad.

NOTE: Switch on PC board must be on NICAD to recharge batteries. Switch to ALKALINE for non-rechargeable Alkaline batteries.

MAX-100 has been designed with a battery charger circuit connected to the rear power jack. When external power is applied to the jack, the batteries automatically charge, even when the counter is in use. In order to insure a full charge on the batteries, switch the counter off and charge overnight.

NiCad CELLS

NiCad batteries have been used for the last 50 years in heavy duty rechargeable applications with excellent results.

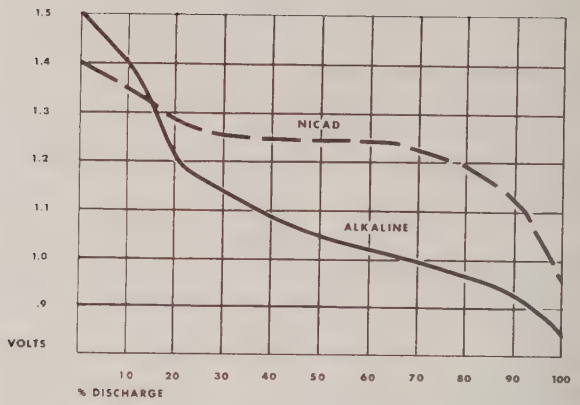

fig.7

They are ideal power sources capable of taking up to 1,000 recharges without requiring maintenance and keeping a relatively constant voltage during discharge.

Only fast charge type AA cells should be used in the MAX-100 since the beginning charge rate may be as high as 100 milliamperes.

NiCad cells have a tendency to self-discharge when standing on the shelf for some time. New batteries should be charged overnight before being put into use.

They recover fully after a recharge, and exhibit no permanent damage. It is not advisable to keep them on charge constantly. An occasional discharge tends to keep them up to maximum capacity.

Studies have shown that NiCad on constant charge for 2 years will drop down to 60% of their capacity on their first discharge. After being recharged, their next discharge is up to 90% of capacity, and continuous use after that will bring them back to full capacity.

Be careful of completely discharging NiCad cells, or short circuiting them. **Short circuiting can cause overheating damage to the cells.**

The main cause of complete battery discharge is forgetting to turn the counter off after it has been used.

The MAX-100 was designed to current limit at low battery voltage levels and prevent cell destruction due to complete battery discharge. A normal recharge cycle should restore the battery to useful service.

AC ADAPTER/CHARGERS

Two AC adapter/chargers are available from Global Specialties for simultaneous counter operation and battery recharge. Both are capable of 8 volts output at 400 mA. The transformer housings plug directly into the AC wall outlet, with a 6-foot cord for maximum accessibility. Both can fully charge 6 NiCad AA cells in 14 hours.

Model #100-CA1 100 VAC Adapter/Charger
Model #100-CA2 220 VAC Adapter/Charger

AUTO CIGARETTE LIGHTER ADAPTER

For ease of mobile operation, the MAX-100 can be powered with our auto cigarette adapter, allowing simultaneous counter operation and battery recharge from any 12-volt, negative-ground system. It comes with an 8-foot cord for maximum mobility.

Model #100-CLA

LOW LOSS IN LINE TAP WITH UHF CONNECTORS

Enables the user to tap into transmission lines on CB or ham transmitters. The tap is rated at 100 watts of RF power. It comes with 3 ft. cable and 90° phono plug for attachment to the MAX-100

Model #100-LLC

MINI-WHIP ANTENNA

This one-foot-long vertical mini-whip antenna with right-angle phono plug is designed to fit directly in the MAX-100 signal input jack. It can pick up 5 watt CB antenna transmission at a distance of 4 feet.

Model #100-MWA

VINYL CARRYING CASE

A custom designed soft vinyl carrying case is available that provides both protection and adequate room for accessories. (See Figure 8.)

Model #100-CC

RMA 6873C

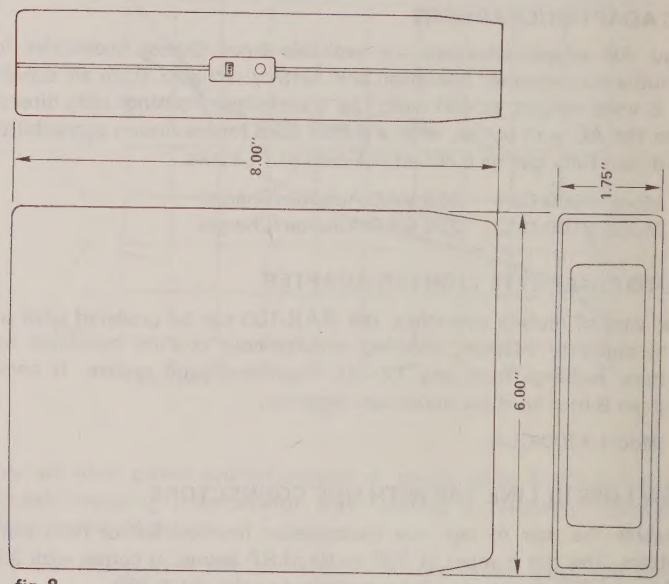

fig. 8

SERVICE AND WARRANTY INFORMATION

FACTORY SERVICE AND REPAIR

Global Specialties will service and repair this instrument free of charge for a period of one full year, subject to the warranty conditions below.

To obtain a return merchandise authorization (RMA) required for all returns, phone our Customer Service Department for an RMA and all shipping instructions: Tel. 800-572-1028 or write:

GLOBAL SPECIALTIES
70 FULTON TERRACE, BOX 1942
NEW HAVEN, CONNECTICUT 06509
ATTN: CUSTOMER SERVICE DEPARTMENT
1-800-572-1028

CANADIAN
AUTHORIZED SERVICE CENTER
BCS ELECTRONICS, LTD.
980 ALNESS ST.
DOWNSVIEW, ONTARIO M3J 2S2
(416) 661-5585

• FX, P R, 33,75

WARRANTY

Global Specialties warrants this device to be free from defective material or workmanship for a period of one full year from date of original purchase.

Global Specialties under this warranty is limited to repairing the defective device when returned to the factory, shipping charges prepaid, within one full year from date of original purchase.

Units returned to Global Specialties that have been subject to abuse, misuse, damage or accident, or have been connected, installed or adjusted contrary to the instructions furnished by Global Specialties, or that have been repaired by unauthorized persons will not be covered by this warranty.

Global Specialties reserves the right to discontinue models, change specifications, price or design of this device at any time without notice and without incurring any obligation whatsoever.

The purchaser agrees to assume all liabilities for any damages and/or bodily injury which may result from the use or misuse of this device by the purchaser, his employees, or agents.

This warranty is in lieu of all other representations or warranties expressed or implied and no agent or representative of Global Specialties is authorized to assume any other obligation in connection with the sale and purchase of this device.

BREADBOARDING SOCKETS LIFETIME GUARANTEE

All Global breadboarding sockets are guaranteed for life. If a socket ever fails to meet your requirements, return it and we will replace it, NO QUESTIONS ASKED.

Specifications subject to change without notice.

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MP MASTER
MA34809

GLOBAL SPECIALTIES
An Interplex Electronics Company
70 Fulton Terrace, P.O. Box 1942
New Haven, Connecticut 06509
(203) 624-3103 • TWX 710 465-1227

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